Chapter 4 REVIEW

Knowledge and Understanding

Select the letter of the best answer below.

1. The underlying reason why atoms ever form bonds at all is
   - **a.** lower energy.
   - **b.** greater stability.
   - **c.** electrostatic forces.
   - **d.** Two of the above are correct.
   - **e.** All are correct.
2. An ionic bond will form between two types of atoms when the ΔEN value is
   - **a.** less than 0.4.
   - **b.** between 0.4 and 1.7.
   - **c.** exactly 1.7.
   - **d.** greater than 1.7.
   - **e.** The value is dependent on the size and number of the atoms forming the bond.
3. In general, the melting points and boiling points of Group 1 metals are lower than Group 2 metals in the same period because
   - **a.** Group 1 metals are smaller than Group 2 metals in the same period.
   - **b.** Group 1 metals are more reactive than Group 2 metals.
   - **c.** there are more valence electrons and a stronger positive charge in Group 2 metals.
   - **d.** Two of the above are correct.
   - **e.** All are correct.
4. Chemical bonding can best be predicted and explained by the properties of
   - **a.** valence electrons.
   - **b.** inner core electrons.
   - **c.** the effective nuclear charge.
   - **d.** the nuclear charge.
   - **e.** the atomic radius.
5. Which of the following statements about electron pairs is false?
   - **a.** They can be bonding or lone pairs of electrons.
   - **b.** They arrange themselves around a central atom through three-dimensional space.
   - **c.** Repulsive forces keep them spread apart.
   - **d.** The repulsive force between all electron pairs is equal.
   - **e.** Only the electron pairs in the valence shell of atoms are involved in bonding.
6. What information cannot be predicted by the Lewis structure of a molecule?
   - **a.** electron arrangement in the valence shell of each atom
   - **b.** molecular shape
   - **c.** which electron pairs are lone pairs and which are bonding pairs
   - **d.** which bonds are single, double, or triple bonds
   - **e.** All of the above information can be predicted by Lewis structures.
7. The structure of metal objects consists of
   - **a.** single large crystals.
   - **b.** randomly arranged atoms.
   - **c.** microscopic crystalline grains.
   - **d.** alternating negatively and positively charged particles.
   - **e.** All of the above are correct.
8. The smallest ratio of sodium ions to chloride ions in solid sodium chloride is called a
   - **a.** unit cell.
   - **b.** molecule.
   - **c.** crystal.
   - **d.** formula unit.
   - **e.** None of the above are correct.
9. Which one of the following is an example of an intermolecular force?
   - **a.** hydrogen bond
   - **b.** covalent bond
   - **c.** ionic bond
   - **d.** metallic bond
   - **e.** None are examples of intermolecular forces.
10. Oxygen gas and nitrogen gas are both non-polar molecules, but can dissolve, sparingly, in water because
    - **a.** water is a universal solvent.
    - **b.** of ion-induced dipole forces.
    - **c.** of dipole-induced dipole forces.
    - **d.** of dispersion forces.
    - **e.** of the ability of every substance to dissolve in any solvent, however sparingly.
11. Which of the following is not a property of ionic compounds?
    - **a.** conducts electric current in solution
    - **b.** ductile
    - **c.** brittle
    - **d.** does not conduct electric current as a solid
    - **e.** none of the above

12. The ΔEN value between elements in a bond is 0.3. This makes the type of bond

a. ionic.
b. polar covalent.
c. mostly covalent.
d. metallic.
e. mostly ionic.

13. Which type of hybrid orbitals is likely to exist for the sulfur atom in the bonds for the molecule sulfur hexafluoride, SF_6?

a. sp^3d^2
b. sp^3d
c. sp^3
d. sp^2
e. sp

14. Which of the following statements about water molecules is false?

a. One oxygen atom in a water molecule can bond with as many as six hydrogen atoms in other water molecules at the same time.
b. Hydrogen bonds in solid water (ice) are longer than they are in liquid water.
c. Water molecules are permanent dipoles.
d. Hydrogen bonds are responsible for many unique properties of water.
e. Hydrogen bonds in water are as strong as covalent bonds.

Answer the questions below.

15. Atoms of which combinations of elements tend to form ionic bonds? Why?

16. Atoms of which types of elements tend to form covalent bonds? Why?

17. Explain the process of hardening of a metal and why it works.

18. Electrons are said to be "delocalized" in metallic bonds.

a. In your own words, describe what this means, and how it is different from the locations of valence electrons in ionic and covalent bonds.
b. How does the "delocalization" of electrons in metallic solids explain "malleability," the property unique to all metals?

19. Explain why ionic solids are brittle.

20. Explain how single bonds form, based on quantum mechanical concepts.

21. What experimentally observed property of methane makes it necessary to invoke the concept of hybridization to explain the structure of methane?

22. List the five possible shapes of hybrid orbitals.

23. Describe two ways in which a non-polar molecule can temporarily become a dipole.

24. Explain why symmetrical molecules are non-polar and asymmetrical molecules can be polar.

25. If the polarity of the molecules of a substance is known, what other properties of that substance can also be known? List at least four properties.

26. List two properties of metallic and ionic (non-metal) solids that are

a. the same.
b. different.

27. List two properties of ionic solids and polar molecular solids that are

a. the same.
b. different.

28. Explain why a molecule such as boron trifluoride, BF_3, has no dipole, but a molecule such as water, H_2O, is polar, even though they are both symmetrical molecules.

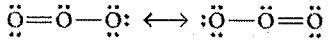
Thinking and Investigation

29. The melting point of rubidium chloride is 718°C and its solubility in water is 91 g/100 mL. The melting point of rubidium bromide is 693°C and that for rubidium iodide is 646°C. Would you predict their solubility in water to increase or decrease as the melting point decreases? Why?

30. Use the periodic table to help you draw the orbital diagram (for the valence shell only) for the following elements and their most likely ions (if there is one):

a. calcium
b. nitrogen
c. aluminum
d. neon
e. beryllium

31. Earlier in this chapter, ozone is pictured as a resonance structure as shown below:



a. Analyze the Lewis structures and apply VSEPR theory to predict the electron group arrangement and the molecular shape of the ozone molecule. Use Lewis resonance structures to roughly sketch the structure.
b. Experimental evidence shows that the bond angle in the molecule is 116.8°. With this fact in mind, how likely is your answer to part (a) to represent the actual molecular structure?

32. Predict which bond in the following groups is the most ionic in character. Calculate ΔEN for each to check your predictions.

a. H–Cl, H–Br, H–F
b. Na–O, Li–O, K–O

33. Classify the following bonds as mostly ionic, polar covalent, or mostly covalent by looking at the location of the elements on the periodic table. Check your classifications by calculating ΔEN for each.

a. Li–Cl **c.** C–N

b. S–S **d.** Na–O

34. Use the periodic table to help you write the condensed electron configuration for the following elements and their most likely ion (if there is one):

a. lithium **c.** chlorine

b. argon **d.** phosphorus

35. Use VSEPR theory to identify the electron group arrangement (VSEPR shape), the molecular shape, and the bond angle of the following molecules whose central atoms have

a. 4 bonding pairs and 1 lone pair.

b. 6 bonding pairs and 0 lone pairs.

c. 3 bonding pairs and 2 lone pairs.

d. 3 bonding pairs and 0 lone pairs.

e. 2 bonding pairs and 2 lone pairs.

f. 4 bonding pairs and 2 lone pairs.

36. Determine whether each of the following compounds will be polar or non-polar.

a. CO_2 **c.** SiO_2

b. H_2S **d.** PCl_3

37. In a lab, two liquids of 200 mL each are mixed together in a container. The resulting volume is 390 mL, even though none of the two liquids were spilled in the process. What must have happened for this to have occurred?

38. Describe an investigation that can be used to determine if an unknown liquid is polar or non-polar. Include the conclusions of this investigation that would allow you to determine the liquid to be polar or non-polar.

39. In Lewis structures, co-ordinate covalent bonds look the same as regular covalent bonds. How are they different from a regular covalent bond?

40. In the 1950s, the reaction of hydrazine, N_2H_4, with chlorine trifluoride, ClF_3, was used as a rocket fuel.

a. Draw the Lewis structures for hydrazine and chlorine trifluoride.

b. Identify the hybrid orbitals used in each one.

c. Identify the molecular shape and polarity of chlorine trifluoride.

41. Perform an Internet search on the Mohs Hardness Scale for metals. Write a brief report on your findings and include some Mohs scale values for various metals.

42. Use VSEPR theory and Lewis structures to predict the number of bonding pairs and lone pairs around the central atom so that you can identify the VSEPR shape, molecular shape, and bond angle for the following molecules and ions:

a. XeF_2 **c.** SF_5^+

b. BCl_4^-

43. Which compound in each of the following pairs has the higher boiling point? Explain your choice in each case.

a. NH_3 or PH_3 **c.** $SeCl_4$ or $SiCl_4$

b. C_2H_6 or C_4H_{10}

44. For each of the following elements or compounds, predict which would have the higher boiling point and explain how you made your choice.

a. O_2 or N_2

b. ethanol (CH_3CH_2OH) or methoxymethane (CH_3OCH_3)

c. heptane or 2,4-dimethyl pentane

Communication

45. Draw Lewis structures for the following compounds. (A resonance diagram might be required). In each case, count the number of lone pairs and bonding pairs.

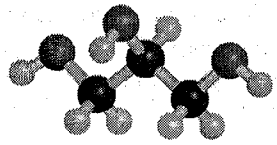
a. SbH_3 **d.** C_2H_2

b. $CFCl_3$ **e.** BeF_2

c. HCN

46. Create a list of standard tests that can be used to test and classify solids. For example, a lustrous, grey substance can conduct electricity in the solid state. Organize these tests in a flowchart and include directions that a classmate could use as a guide for carrying out the tests. Be sure that the order of the tests will minimize the amount of work necessary to draw a conclusion.

47. The structure of a glycerol molecule is shown here.



a. Draw the Lewis structure for glycerol.

b. Draw 3 to 4 Lewis structures for glycerol so that as many hydrogen bonds can form between the molecules as possible.

48. A semiochemical is a molecule that delivers a specific message between individuals of the same or different species of plants or animals. Pheromones are the most well known of these chemicals. Research pheromones and prepare a brief report on your findings. Include a reference to the structure of the chemicals in your report.

49. The rules for drawing Lewis structures for simple molecules were based on molecules having a central atom. Many molecules do not have a central atom but are often written in a way that gives you clues about their structures. In some cases, symmetry allows you to draw half of the molecule and then put the two halves together. In other cases, the formulas are written in a way that reveals the grouping of atoms. You can isolate the groups, draw their structures, and then attach the groups. Draw Lewis structures for the following compounds by applying these concepts.

a. NH_2CH_2COOH **c.** CH_3CHF_2

b. CH_3CH_2COOH **d.** $(NH_2)_2CO$

50. BIG IDEAS The nature of the attractive forces that exist between particles in a substance determines the properties and limits the uses of that substance. Water alone cannot be used to remove greasy stains from fabrics or dishes. Detergents are made up of long molecules that have a water-soluble end (hydrophilic head) and a non-polar hydrocarbon (hydrophobic tail). The hydrophobic tails of the detergent molecules are attracted to the greasy stain and surround it, while the hydrophilic heads stick out, far away from the grease. The heads in turn are attracted to water and can mix with it. Therefore, water with detergent added can remove greasy stains. Draw a series of 2 to 3 simple diagrams to represent this process. Use a straight line with a small ball at the end to represent a detergent molecule.

51. Develop a flowchart or similar graphic organizer that can be used to create a Lewis structure for a molecule or polyatomic ion.

52. Make a series of sketches to show what happens when a positively charged ion approaches a neutral molecule. Explain the meaning of the sketches. For the neutral molecule, use a sphere with evenly distributed positive and negative charges.

53. A dry mixture contains the following solids, all very small (<1 mm diameter): shiny, light-grey nickel balls; shiny, colourless glass beads; wax shavings; and table salt. Draw a flowchart to show how you would separate the mixture into its four separate components. Use your knowledge of the properties of each type of solid to guide you. Your separated fractions should be dry at the end. On your flowchart, add a label to each solid to indicate the class to which each compound belongs.

54. Summarize your learning in this chapter using a graphic organizer. To help you, the Chapter 4 Summary lists the Key Terms and Key Concepts. Refer to Using Graphic Organizers in Appendix A to help you decide which graphic organizer to use.

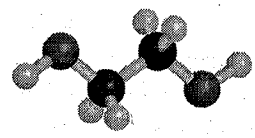
Application

55. A photoelectric cell can be used as a "switch" to activate mechanical devices. Also known as an "electric eye" in this application, a photoelectric cell is an evacuated tube covered on one side with cesium metal. When light strikes the coating, electrons are ejected from the atoms and create an electric current. In the absence of light, the electric current is zero.

a. Why do you think cesium is an effective metal to use in this application?

b. Which other metals might be effective? Why?

56. Ethane-1,2-diol (common name: ethylene glycol), shown below, is commonly used as antifreeze in automobiles.



a. Draw the Lewis structure for ethane-1,2-diol.

b. Based on its structure, would you expect it to have a lower or higher boiling point than water? Explain your reasoning.

c. Based on its structure, would you expect it to be able to dissolve in water? Explain your answer.

d. How do the structural properties of ethane-1,2-diol prevent water from freezing?

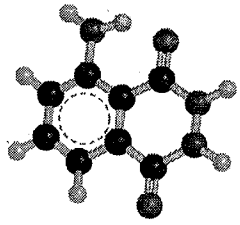
57. Answer the following questions about the element antimony.

a. Write the condensed electron configuration for antimony, Sb.

b. Antimony can have a valence of –3, +3, or +5. Use condensed electron configurations to show how each of these valences must form. In each case, explain why that change makes sense.

c. Antimony is a metalloid. Defend this claim using your answers to part (b) of this question.

58. Chemiluminescence is the ability of chemicals to emit light energy during a chemical reaction. Luminol, shown here, is a chemiluminescent molecular compound that is used at crime scenes to detect trace amounts of blood. When the compound luminol reacts with an oxidizing agent, such as the iron in blood hemoglobin, it emits a characteristic blue glow.

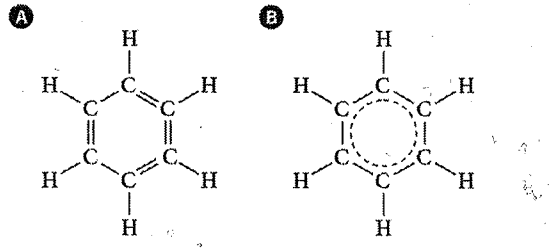


a. Draw the Lewis structure for luminol.

b. Luminol is usually applied as a spray onto a crime scene. Research luminol's polarity and discover what type of solvent would be required for dissolving luminol completely.

c. Continue your research of luminol to discover what the drawbacks are to using such a versatile and sensitive compound at a crime scene. Make a list of some of these drawbacks.

59. Benzene, $C_6H_6(\ell)$, is a clear, colourless, and flammable liquid with a pleasant smell. It is now known to be a potent carcinogen. Before its carcinogenic properties were known, it was used for many applications that exposed it to the general public, such as for decaffeinating coffee, in high-school experiments, and even as an aftershave lotion. Today, it remains an important industrial chemical, but safety regulations govern its use.



a. A benzene ring, C_6H_6, has two resonance structures. One of them is shown here, labelled "A." Draw the other resonance structure.

b. Chemists sometimes draw benzene as shown in the image labelled "B." What does the circular dashed line represent? How does this representation compare with the use of resonance structures? Which form do you think best portrays the structure of benzene?

60. Complete the chart for the following molecules:

Compound	Hybridization Rough Work	Hybrid Orbital Required	Bonding Groups	Lone Pairs	Electron Group Arrangement	Molecular Shape	Bond Angle	Polarity
SnF_2								
NH_3								
PF_5								
SF_6								

61. A lab technician pours sand into a container of marbles to help students visualize interstitial alloys. Explain why this demonstration is a good model for this type of alloy.

62. Molecules of the compound iodine heptafluoride, IF_7, have an unusual shape that is not listed in **Figure 4.31**. The shape is called pentagonal bipyramidal.

a. Draw a Lewis structure for IF_7.

b. Make a sketch to show what you think the molecule looks like. Include bond angles and explain your reasoning.

63. A unique black nail lacquer product forms cracks as it dries when it is applied overtop a layer of nail enamel that has already dried. The effect is stunning: the colour from the undercoat shows through the cracks of the black top coat. The cracks start to form when the top coat is close to being completely dried. Use your knowledge of solids and their properties to analyze the observations and inferences of this process, and form a possible explanation for how this product works.

64. A metal alloy is a solution of metals. Different metals can combine relatively easily with one another to form a homogeneous solid solution because of the nature of metallic bonds. Metal alloys often have a significantly different set of properties than the metals they contain. For example, gold is very soft and would wear away quickly over time. Ten carat gold, often used in jewellery, contains a mixture of gold (42%), silver (12% to 20%), and copper (38% to 46%) to make it more durable over time.

a. In addition to preventing steel from rusting, the addition of nickel to steel has allowed the technology of wind turbines to be more viable in northern climates. Visit The Nickel Institute website to find out how.

b. Cast iron is an alloy of iron that contains 3% to 4% carbon. Research how the properties of cast iron differ from those of pure iron.